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BRIEF REVIEW OF SEWAGE DISPOSAL WORKS IN SOME EUROPEAN CITIES AND COMPARISON WITH THE PENNYPACK CREEK WORKS AT PHILADELPHIA

By George E. Datesman

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Introduction. The use of underground channels to carry off the liquid wastes from dwellings is a very ancient practice.

In the beginnings of ancient Rome there were built large conduits, in use to this day.

On the Island of Crete, the home of the Aryan progenitors of the ancient Grecians, recent excavations show that underground drainage channels were systematically constructed at least 3500 years B.C.

The construction of these channels as a system however may be said to have begun in the nineteenth century.

Scientific and effective treatment and disposal of the liquid wastes was discussed in the last quarter of the nineteenth century, experiments inaugurated and many works constructed during that time; but during the early years of the present century, the art has made much progress, works have been built in accordance with the most successful lines of experiment, and many additions made to the earlier works.

Sanitation. While sanitation comprises many branches, that represented by the term sewage disposal is one of large influence upon the general health of a community.

Prior to the introduction of sewage systems in large cities, death rates were high, and for centuries at intervals of a few years or decades, their populations were swept away by plague or pestilence, fostered and spread by admixture of noisome liquid wastes with the drinking water.

Repetitions of these visitations were accepted as natural, until modern science showed that by the introduction of proper systems for carrying away liquid wastes, the mortality could be lessened.

Striking examples are the city of Havana, and the Canal Zone, made habitable and safe by the introduction of sanitary conveniences.

Municipalities, especially in the crowded European centers, took up the matter of improving old conditions with vigor, full size experimental installations were made, gradually developing into complete systems for the collection and disposal of the sewage.

The agitation for better sanitary municipal surroundings has given rise to keen debates and has set up many champions of a radical change, calling for the exclusion of sewage matters from streams and rivers.

Calmer judgment and extensive experiments have tempered these views until at present it is recognized that the streams themselves are and have been effective agents in transforming organic or putrescible matter into a mineral or innocuous state up to a certain limit, dependent upon the amount of available oxygen in the water.

European conditions. The examinations of sewerage systems in European cities are valuable on account of the concentrated population, a prototype of our own in another half-century, and the results achieved by the introduction of sewage treatment systems in lowering their death rates, even with a water consumption of from one-fourth to one-sixth of that in our American cities. This, resulting in a far more concentrated sewage, calling for different treatment than our own, necessitates also the treatment of a volume of storm water when polluted by the sewage, ranging from four to six times the dry weather flow, a condition which does not arise with our more dilute sewages.

By reason of their concentrated populations and the smaller size of European rivers, with their small diluting volumes, the urgency of installing sewage treatment works has been greater, to protect their restricted water supplies and to avoid nuisances that would in some cases make their cities noisome places of abode.

Again, on account of their nearness to Asiatic cities, the homes of plague and pestilence and their open harbors, sanitary safeguards are essential.

Owing to restricted parking areas and the possibilities of river embellishment, by the removal of sewage pollution, they have been enabled to make of their rivers the most attractive features of their cities, for bathing and the enjoyment of people in their hours of relaxation.

American conditions. The American cities have grown rapidly from villages, and the village practice of building a culvert to the nearest stream has until recent years, survived. The drains from various villages have grown into a system with many outlets discharging crude sewage into the larger streams.

Large streams like the Schuylkill River suitable for water supply have gradually been eliminated from the lists of available sources, the rivers themselves have become septic tanks, and of recent years, even rivers like the Delaware and Hudson have been polluted, so as to require effective treatment before their waters can be used for domestic consumption, a prodigal waste of natural resources.

A few years ago the old fashioned cesspool was in vogue and we can remember when protests were filed against the building of sewers. Now, since no block of dwellings can be disposed of without them, builders solicit drainage facilities as the first step in the improvement.

A few years ago black, dirty, sewage polluted water was consumed by local residents without question and affliction with enteric diseases in consequence was taken as a matter of course. The improved water supply has educated our people to other views.

In port operations, formerly, any filth could be thrown from vessels or dumped into the river. Today it is recognized that to compete for the world's commerce, we must remove from sight and smell all nuisance.

Today pollution of water supplies will not be tolerated, and a reduction in the deaths due to preventable disease appeals so strongly, that the great insurance companies have banded themselves together, with millions of capital behind them, to study their causes and remedies with a view to stamping them out.

We in America are just learning to be less prodigal and to devise ways and means to conserve our advantages, to protect our streams, to be dissatisfied with their pollution with sewage; but it will take some educational compaigning before the people at large will understand the value to the communities of sewage treatment.

Advances in the art. The advance made in the art, due to large sums spent in full size experimental installations, in efforts to free natural water courses from pollution, has been steady and positive, each forward step taken after experience in operation or research warranted it.

In the first instance, farms irrigated with sewage were operated, but this practice has been abandoned, except where by reason of the great cost of the installation, it is not practicable to change the treatment.

Screening and tank treatment, sometimes coupled with sand filtration have been substituted in some instances.

Throughout England, where rivers are comparatively small, plants are undergoing reconstruction, and some form of bacterial treatment in beds is being added to the preliminary treatment. In some cases it has been found to be economical to turn the earlier works into scrap and build entirely new as at Leeds.

In English sewage disposal plants, the disposal of sludge, except where it is carried to sea, has been generally inadequate. This is now considered by many the most vital problem.

In Germany, by several processes the problem of sludge disposal has been successfully solved.

As to the present status of the art the following statements may safely be made:

Sewage even of exceptional concentration can be effectively treated, so as to secure a clear, odorless, sparkling, non-putrescible effluent before discharging into a stream, the securing of which is a matter of cost and therefore an economic as well as a constructive problem.

Sludge resulting from sewage treatment can be rendered innocuous, practically inodorous, wholly unobjectionable, after which it may be dealt with in various ways.

Desired results may be secured by certain combinations of treatment at a fraction of the cost of other recognized scientific methods of treatment, in satisfactory operation.

Relation to water supply. It is considered by some eminent sanitary engineers, that they are justified in placing sewage disposal next in importance to water supply in the list of public utilities. This is based upon the value of protecting the streams from nuisance, to conserve sources of water supply and to protect the health of the people.

As a water supply is taken from a river, its application to a populous community produces sewage and as its natural destination is a return to the stream, used possibly again for water supply, it gives rise to an economic problem as to the proportionate share which should be borne in the treatment of both the water and sewage.

The theory of excluding all sewage from return to a stream, held some years ago is untenable, and with this recognized and the necessity of utilizing the diluting volume of the river and its available oxygen to continue the treatment begun in disposal works, the problem resolves itself into an economic one.

The uses to which the waters of a river are to be applied are controlling factors in the standard of effluent to be secured.

The comparative economy of treating sewage to a high degree of purification, or of taking a lower standard and increasing the degree of water treatment, must be solved by each community.

When comparing the amounts of available chlorine required in water and sewage effluent treatments it has been found that of three turbid raw water supplies, the average amount of available chlorine required to render the manufactured product free from bacteria resembling B. Coli is p.p.m. 0.7; of three other raw surface waters 0.3; of four examples of sand filter effluent, there were required 0.33.

For the effluent of sewage works under average conditions, which had been subjected to settlement, there were required 6 parts; that which had passed percolating filters, 3 parts, and that which had in addition been subjected to secondary settling, 2 parts.

In general therefore it is cheaper to treat water when practical disinfection can be secured by the admixture of from 0.3 to 0.7 p.p.m. of available chlorine instead of attempting to secure an uncertain comparative result in the treatment of sewage effluent by the admixture of from 2 to 6 parts, with a probability of having to resort to an equal amount of treatment for the water notwithstanding the sewage treatment.

In Germany, with its concentrated populations, rivers are considered by the rivers boards as proper places for the disposal by dilution of sewage submitted to fine screening and settling tank treatment, from which rivers are taken the water supplies usually from driven wells or filter galleries along their banks.

Judging from the exceptionally low typhoid death rates in these cities any condemnation of the practice must be supported by arguments from other sources.

City systems. Old Frankfurt, Dresden, London. Description of collecting systems, and local river results.

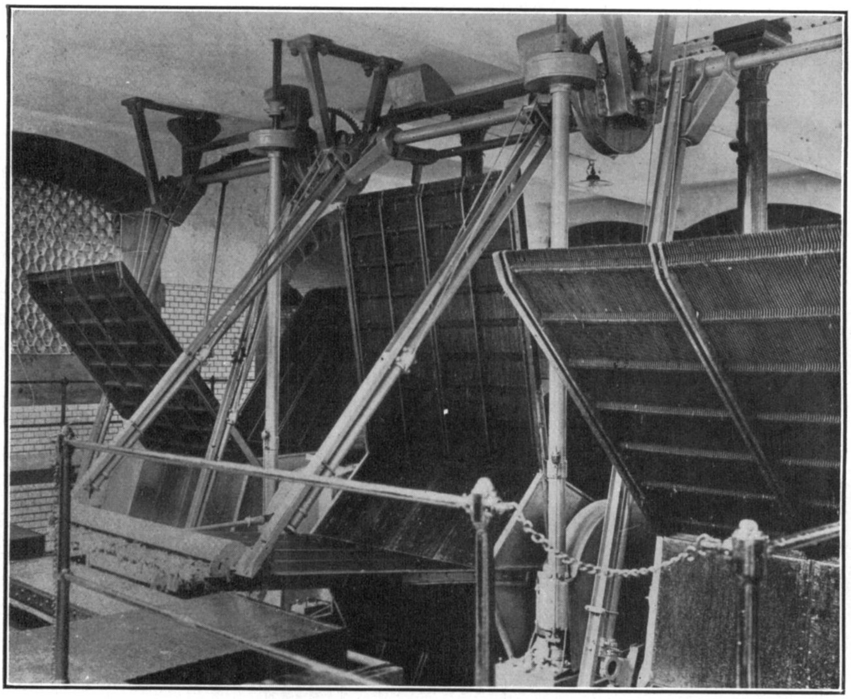
Sewer sections. Two views Wiesbaden. Description of materials and methods of construction, purposes and accomplishments referring to cleanliness, lack of odor and smoothness.

Irrigation farms. Two views Berlin. Berlin: Description of length of force mains; areas of farms in service 22,850 acres; applicability of farms; rate 25,000 gallons per acre; force mains 9 to 15 miles long.

German works. Frankfurt, Hamburg, Dresden.

English works. Birmingham, Bradford.

Grit chambers. Frankfurt, Huddersfield. Sewage reaching treatment works from a combined sewer system must be subjected to passage through a grit chamber to remove sand and coarse gravel. This is accomplished by an increased flow area, to reduce the velocity to 15 inches per second or less. The types in use in Frankfurt, Dusseldorf and in the Emscher district are good examples. Deposited solids are usually removed by elevator bucket dredges having transverse motion on tracks. This admits of operation without putting the grit chamber out of service.

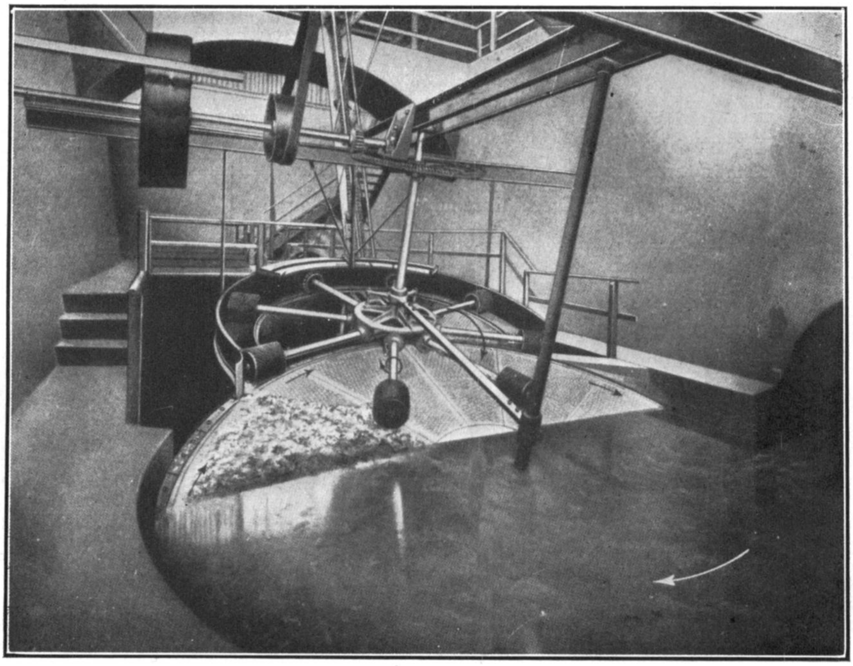


FINE RAKES OR SCREENS AT FRANKFURT A. MAIN

Screens. Hamburg, Frankfurt, Dresden, Bolton. Screening in England is for the purpose of removing such solids as would clog pumps or would be not readily reduced in tank treatment, therefore it is coarse screening the bars being spaced about 2 inches.

In Germany, however, it is considered in many places as a complete and efficient treatment, therefore their manufacture and maintenance have received much more attention. Usually there is a coarse screen of about 3 inches spacing composed of bars to protect pumps or valves. The screening processes proper consist in the main of three types designated as Hamburg, Frankfurt and Dresden.

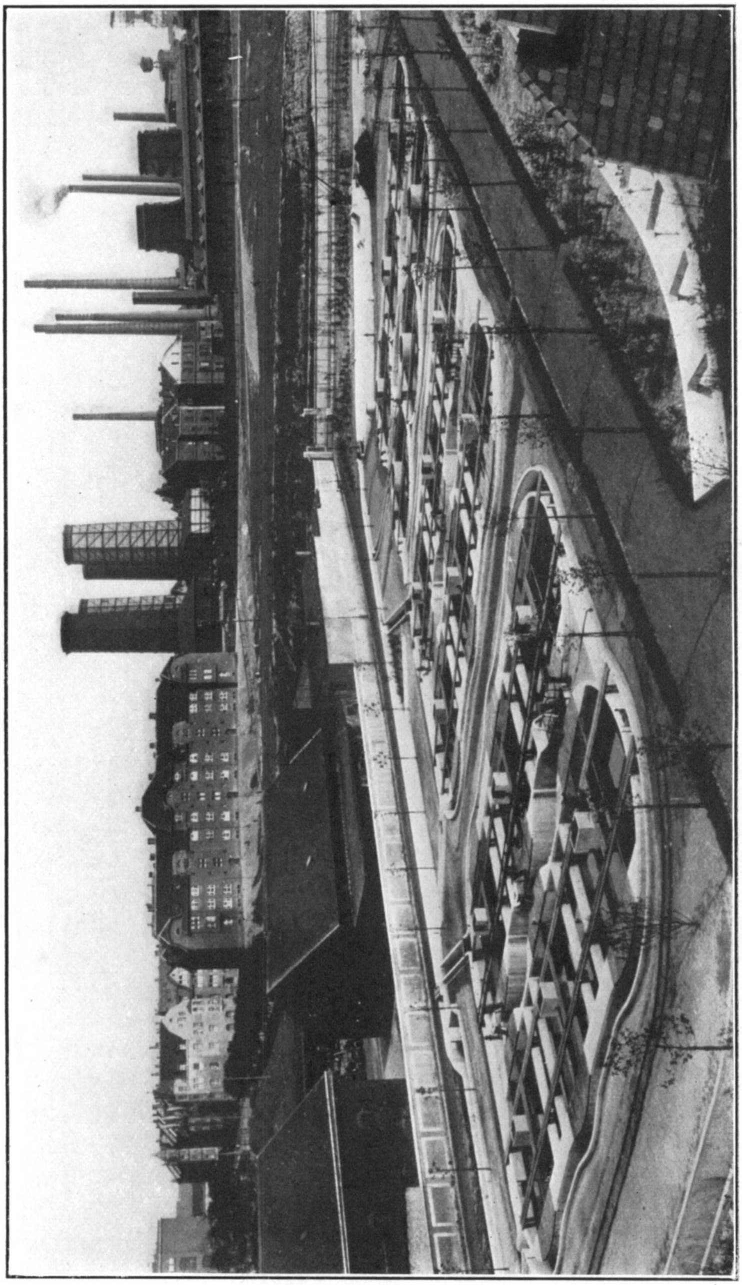
The Hamburg type consists of a curtain inclined at an angle running over drums, brush cleaned. The apertures of the screen are about $\frac{3}{8}$ inch. Where there is a large tidal range and fluctuating depth in the sewers, this is most effective and can be operated with slight nuisance although it is cleaned by brush with difficulty.



Fine Screen of Reinsch Type, Dresden, Germany

The Frankfurt screen consists of five vanes cleaned by a comb the prongs of which alternate with the spaces of the screen. The combings are passed to a table which disappears under a knife edge, the scrapings going to a belt, the screen being easily cleaned and very efficient.

The Dresden screen, introduced in about fifty European plants in Germany, Austria and Russia is the most improved and simplest in its operation. The cleanliness that can be maintained is hard to



Emscher Tanks Showing Proximity of Buildings, Sewage Disposal Works at Essen-Nord, Germany believe unless seen, being entirely without nuisance or objectionable features. The spacing is about $\frac{1}{12}$ inch. Its efficiency will average over 50 per cent solids removed. Screens however effective cannot compete with properly designed tanks.

Tanks. Frankfurt, Birmingham, Essen 2. Without entering into the comparative merits of settling, septic, sedimentation, Emscher or other forms of tanks, a number of types are shown.

Where the sizes of rivers and the consequent dilution is large, and water supplies are not jeopardized, the rivers boards of Germany have after examination pronounced fine screening of sewage a sufficient protection of the rivers.

Where smaller rivers must be used for final disposal or water supplies must be protected there is added some form of tankage treatment.

Septic tanks as at Wilmersdorf deal with a concentrated sewage, are foul smelling though the final effluent is satisfactory.

In sedimentation tanks as at Frankfurt, each unit has a storage period of one and one-half hour; cleaning is resorted to once a week. The type tank involves the placing of a unit out of service when being cleaned, resulting in odors noticeable underground at 150 feet distance.

Throughout England the septic tank is in use designed for storage periods of from twelve to twenty-four hours.

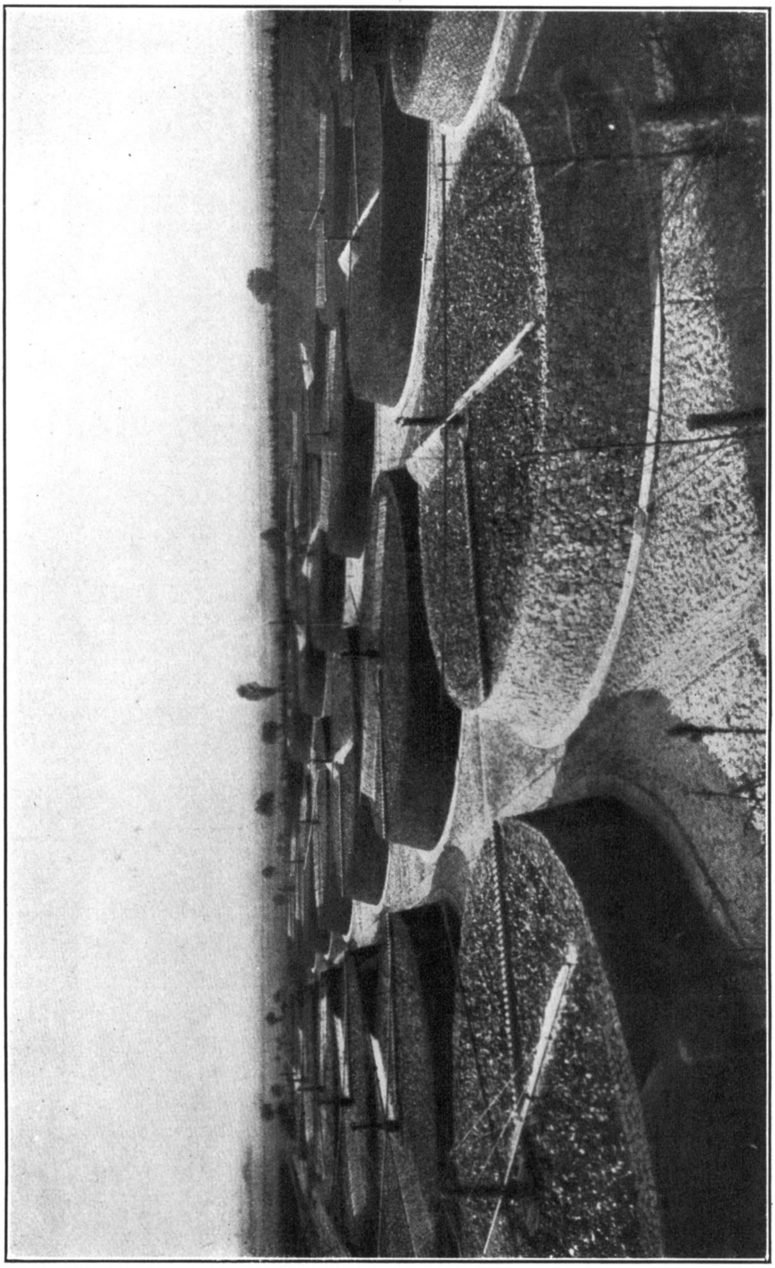
The difference between the German practice of about two hours and the English practice of eighteen hours storage, calling for from five to ten times larger tankage area, is due to the smallness of the English rivers, and the necessity of taking out as large a percentage of solids as practicable.

Methods of cleaning tanks of deposit are various, that at Bolton, consisting of a squeegee having considerable merit.

At Frankfurt the sloping sides and bottom enable the sludge to flow to a central sump, whence it is pumped to centrifugal dryers.

Compare the area of the tanks in Birmingham (12 acres) for 900,000 inhabitants with that of Essen Nord ($\frac{1}{2}$ acre) for 190,000 which illustrates the difference in area as given above, required according to the practice in these two countries.

The so-called two-story tanks called Emscher tanks because used in the Emscher district are two fold in their operation. They provide a sedimentation chamber for about two hours storage, and a digestion chamber for sludge, there being a diaphragm to separate the liquid



Percolating Filters at Wilmersdorf, Germany from the solid parts of the sewage. The gases generated by the decomposing sludge do not pass through the sedimentation chamber, therefore the liquid remains fresh as distinguished from septic or smelly sewage. The biological processes carried on in the digestion chamber successfully mineralize the sludge, so that when withdrawn usually by hydraulic pressure, due to difference in head between tank water and sludge outlet, the product is without objectionable odor, and is like garden soil, suitable for filling in low ground if not utilized for fertilizer.

The tank can be cleaned without placing out of service, and is today on many points the most efficient type in use.

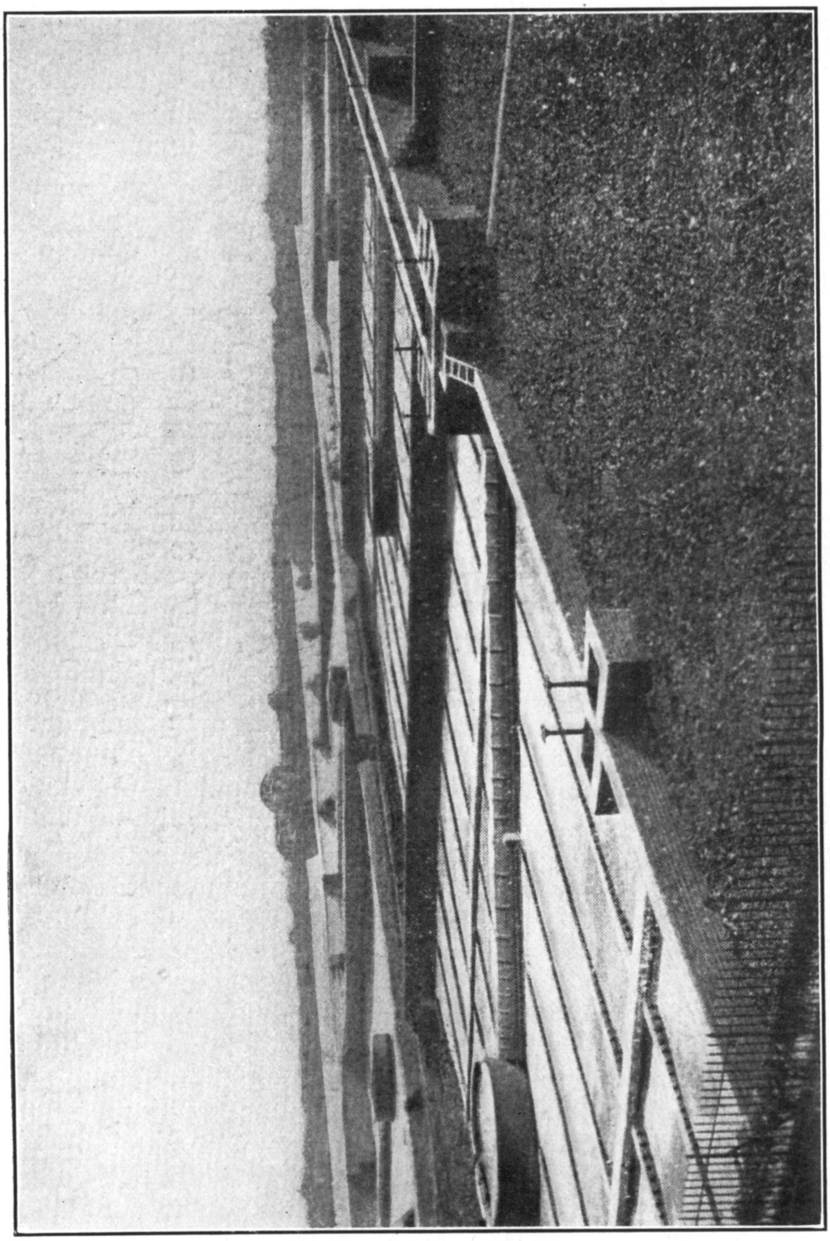
Tank treatment even with long storage periods without supplementary treatment is not sufficient to prevent extreme pollution of the small English rivers, whereas with the larger German rivers, it is efficient, with short storage periods.

Contact beds. Sheffield. A form of bacterial bed in use largely in England and America is the contact bed, consisting of a basin enclosed by walls, filled with cinders, fine stone or other materials, into which sewage, usually after being submitted to tank treatment, is admitted slowly, allowed to stand some hours, then slowly emptied, and allowed to stand empty for some hours, the oxygen admitted during the withdrawal of the liquid serving to provide food for the bacteria acting upon the solids attached to the surface of the material in the bed. The so-called slate beds may be so classed because of the similarity of operation.

Two good examples are at Manchester and at Sheffield, the first caring for the sewage of about 250,000, the latter of about 470,000 inhabitants.

The process is regarded as effective but as the amounts that can be treated are small, about 500,000 gallons per acre per day, about one-fourth of the amount which may be treated in other more rapid processes, percolating filters for example, with a consequent larger area and larger maintenance charges, more intensive processes are talked about, but as much capital is locked up in such large plants it is difficult to make radical changes.

Percolating filters. Wilmersdorf, Birmingham, Huddersfield, Bolton, Salford. Percolating filters consist of beds of cinder, broken stone, gravel or other hard material, thoroughly underdrained, upon which the sewage, subjected to preliminary treatment, is applied by some form of distributor, usually to spray the liquid; rotating arms,



CONTACT BEDS AT SHEFFIELD, ENGLAND

longitudinally travelling trough, fixed nozzles, or by means of a net work of perforated pipes laid on the surface of the filter. With the exception of the circular filters 65 in number at Wilmersdorf near Berlin with rotating arms, and a few small scattered examples, there are none of these beds in Germany, although experimental installations have been in use, and their ultimate use is forecasted, notably in Hamburg and Leipzig.

An experimental station of large size has been in operation in connection with the work at Paris, France, as a result of which the speaker was informed by M. Verrière the chief engineer, that in the forthcoming report for the remodelling of the system, percolating filters would be recommended, in place of the existing farms.

In England the use of the percolating filter is most extensive, not as a matter of choice but from necessity.

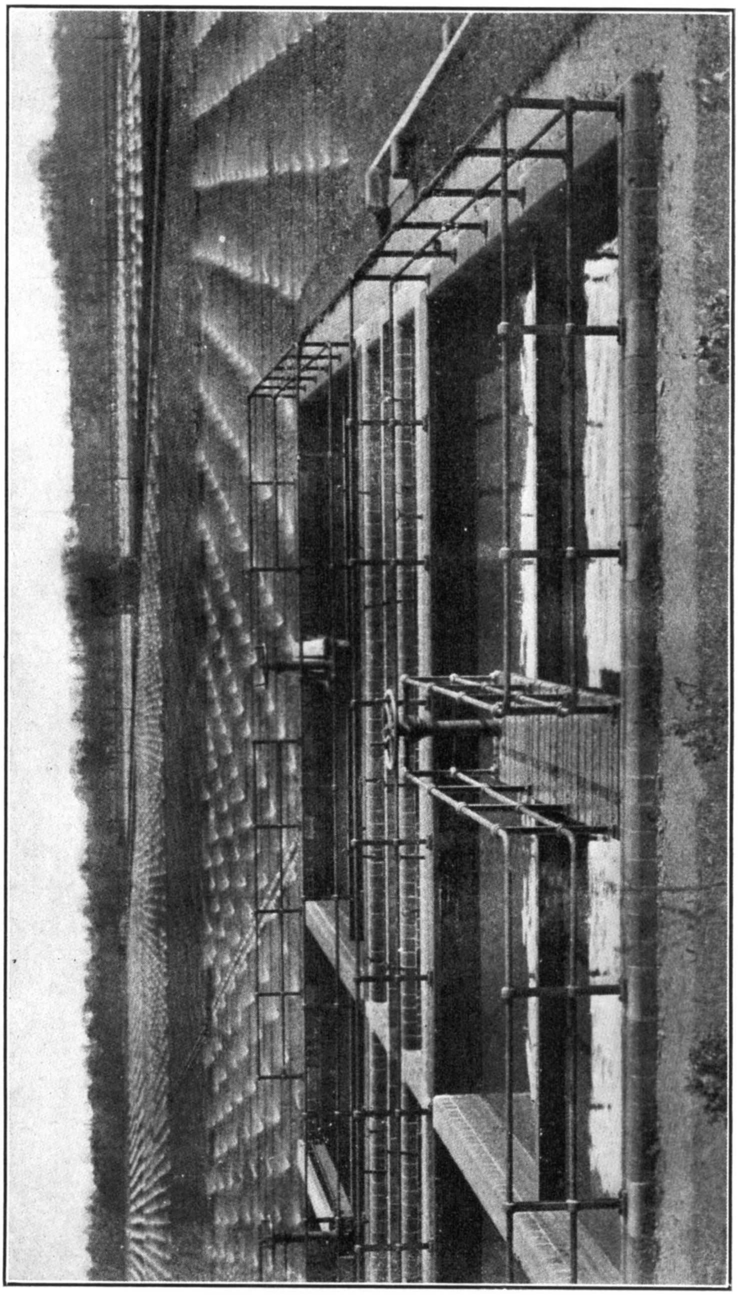
The prevalence of cities with large populations, and the many manufacturing villages forming a chain between, with the comparatively small sizes of the rivers and the great amount of pollution which reaches them, in some cases equalling their flow volumes, have forced more complete treatment of waste liquids than can be obtained by screening and tank treatment alone. This is especially the case in the manufacturing sections, Warwickshire, Lancashire and Yorkshire. Ten years ago it was the view of Sanitary Engineers that septic tanks would reduce and liquefy 90 per cent of the sludge deposited in them; now it is known that between 10 and 20 per cent is the average reduction.

Within twenty years millions of pounds sterling have been expended upon works, but some are being consigned entirely to the scrap heap, as at Leeds, many others are being planned to supplement present treatment by percolating filters, and many are in a process of alteration.

When it is considered that by resorting to these filters the rate of treatment for English sewages can be doubled over the best contact bed system, the matter of area of ground and construction cost alone shows economy.

With strong English sewages composed largely of manufacturing wastes, there is considerable odor from these spraying filters. The small white moths or flies that infest them are an intolerable pest. Experience shows that this nuisance is greatly reduced by surrounding the filters with close stone walls, and placing a fine surface medium.

Sludge disposal. Of all matters reaching a sewage treatment plant, that of proper disposal of the sludge, or residue from tankage



Silt Tanks and Percolating Filters, Birmingham, England treatment is the most serious. A dozen plants can be named, the efficiency of each of which from an operating standpoint is unquestioned, with the single exception of sludge disposal. The methods of disposal vary with the local conditions. They comprise, irrigating on farm land, underdrained lagoons, burying in trenches, pressing and drying, centrifugal drying machines, briquetting and burning. canal boats to farms, steamer to sea, digestion in tanks and drying on sand beds, then used for filling.

The effectiveness from the standpoint of lack of nuisance about the works is as follows: (1) digestion, drying and filling, (2) steamer to sea, (3) drying under heat. The remaining methods are ineffective.

1. The speaker has stood in the center of a 6-acre tract of air dried sludge 50 per cent moisture, of depth varying from 3 to 12 feet, in damp weather, without detecting any more odor than would be noticed from a freshly ploughed unfertilized field. Example—All over the Essen district.

2. Pumping to steamer and disposal at sea is positive in the removal of all nuisance, except during cleaning of tanks. Examples—London and Manchester.

3. During cleaning of tanks and during drying by centrifugals, it is smelly within the building, after drying by heat, there is no further objectionable odor. Example—Frankfurt a. Main.

It may positively be asserted therefore that with certain treatments the sludge problem is satisfactorily solved.

When sufficient fats are present in the sludge (about 25 per cent) they may be profitably recovered as at Bradford.

Notable treatment works. Notable as being the best of their kinds are the following works:

Hamburg—Grit chamber screening and dilution in the Elbe.

Dresden—Grit chamber andfine screening with dilution in the Elbe.

Vienna—Efficient collecting systems with dilution in the Danube.

Frankfurt a. Main—Grit chambers, screens, settling tanks, sludge dried in centrifugals, further dried by heat and burnt under boilers to produce electric current.

Wilmersdorf—Primary settling tanks, percolating filters, secondary tanks, sand filtration, sludge in lagoons.

Cologne and Dusseldorf—Fine screening and tankage, with dilution in the Rhine.

Berlin and Paris—Farms.

London—Screens and tanks with dilution in the Thames, sludge to sea.

Manchester and Sheffield—Screens, tanks and contact beds.

Birmingham—Detritus tanks, settling tanks and percolating filters, Sludge to lagoons.

Salford—Grit chambers, settling tanks, roughing filter, percolating filters, sludge mixed with chemicals, pressed and dried.

Many others will outclass these when new works shall be in operation.

River fronts. One of the most noticeable results of the establishment of sewage disposal works, is in the ability to improve and embellish river fronts.

In London not many decades ago the stench from the sewage polluted Thames invaded the Houses of Parliament and pleaded the cause of sewage treatment. The cleaning up of the Seine at Paris, the Spree at Berlin and other rivers was accomplished only after centuries of warning sounded by the periodical visitation of pestilence. River nuisance has been successfully avoided in European cities by the construction of interceptors along the river banks.

When a German engineer was asked by a prominent sanitarian from New York how they could prevail upon their people or government to vote the money for sewage disposal he declared it was "due to what would be not understood by the people in America, viz.: 'Culture.'" Views of Dusseldorf and Dresden emphasize the possibilities for beautification and commercial development along our Schuylkill River and certain portions of the Delaware River, after the removal of sewage pollution.

Lessons. The choice of a certain process can not be made because of its reputation for effectiveness, but the design must be determined upon only after all phases of the local conditions are considered, starting with the characteristics, size and volume of the river into which final disposal is to be made, and adopting the most economical system, the effluent from which will not unduly overload the river, and which will utilize the available diluting capacity of said river, or parts of a river.

The lessons learned from an inspection of European cities may be briefly summed up as follows: Collecting systems are designed with the most minute attention to economy, therefore along scientific lines.

The quality of material and workmanship in sewer construction are superfine, due in a measure to mechanics wages being one-third of ours.

For the best developed screening appliances we must look to Germany.

Tanks, both on account of economies in areas and scientific design for construction and operation have been developed to a better standard in Germany than elsewhere.

Percolating filters, and the operation thereof may be best studied in England. Scientific experimentation on this system has been more thoroughly carried out in Paris.

The investigations upon river dilution have been carried on more thoroughly in Germany.

Sludge disposal, except where it is carried to sea, has not been solved in England. In Germany, it has been satisfactorily solved by several methods.

The English sanitary world is hopeful that we are on the eve of developing a more intensive, economical and effective means of treatment than the percolating filter.

Having the advantage of observing the operation of all types of disposal works in European cities, lacking the prejudices of the Germans and English against the works of each other, the American Engineer is fortunate in that he may assimilate the best from each, and by proper combinations, with his ingenuity adapting and improving on their plants, he may and in certain instances has produced works which may be said to be the last word in sewage disposal.

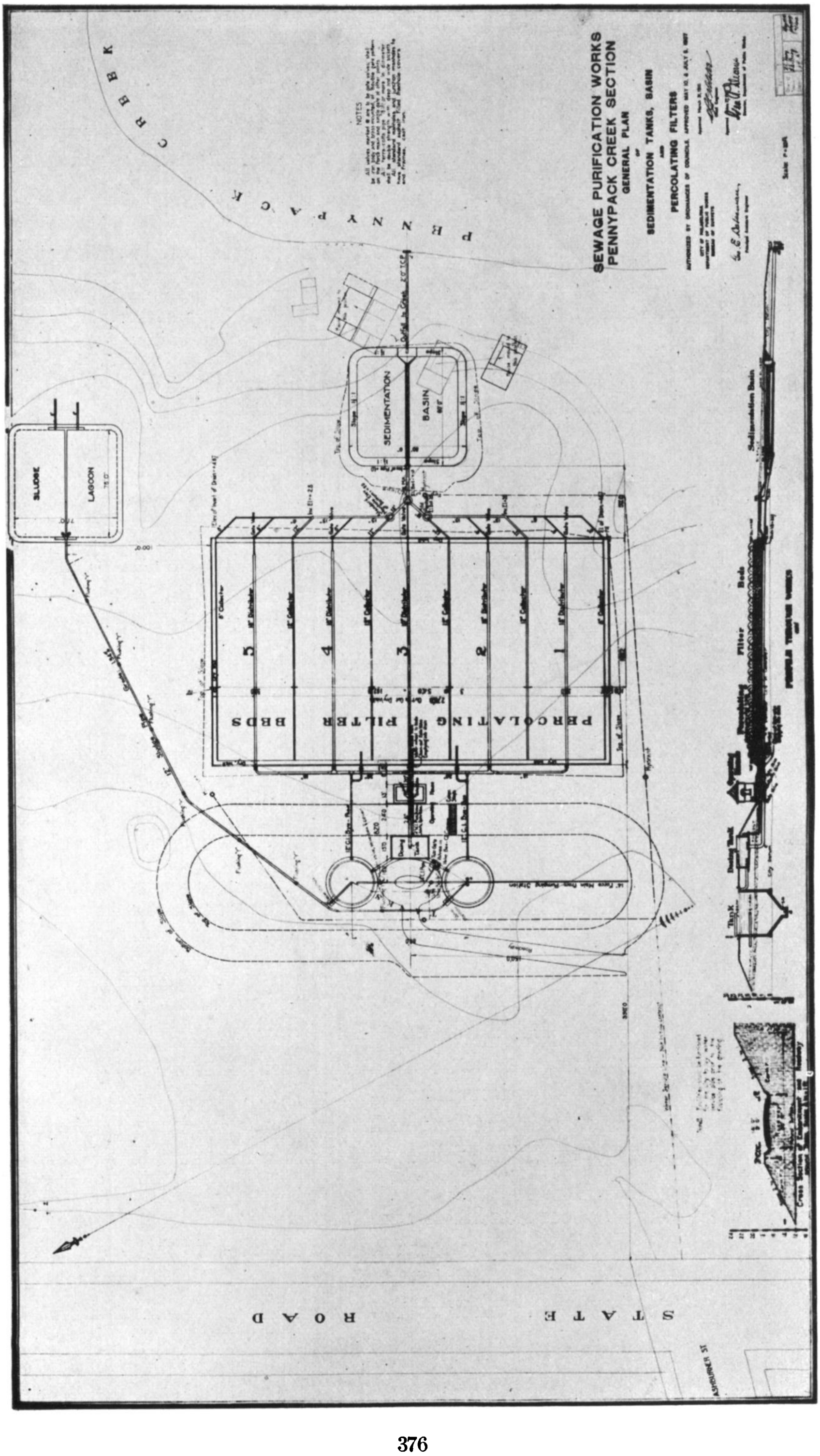
PHILADELPHIA

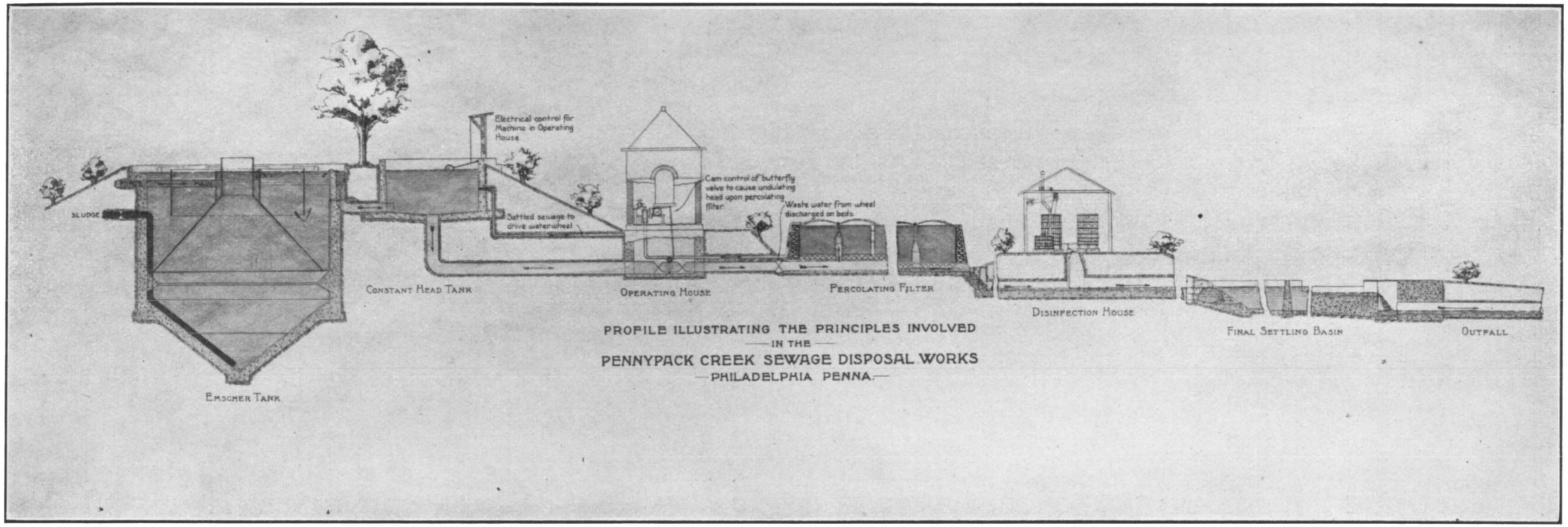
Testing station. For two years (1909–11) the city of Philadelphia operated an experiment station in which various methods and combinations of sewage treatment were studied and their comparative merits determined.

Pennypack Creek. Early in 1912 a sewage treatment works was completed, which had for its object the restoration of the polluted Pennypack Creek, and the elimination of nuisance from three city penal or charitable institutions and the village of Holmesburg, which menaced through the said creek, the intake of the Torresdale water filters, supplying two-thirds of the water consumed by the entire city.

Collector. A collector has been built along the creek to which is diverted the dry weather flow from a number of combined sewers and the whole flow from the city institutions.

Works. After passing a small grit chamber the sewage is pumped by two horizontal centrifugal pumps operated by Westinghouse gas

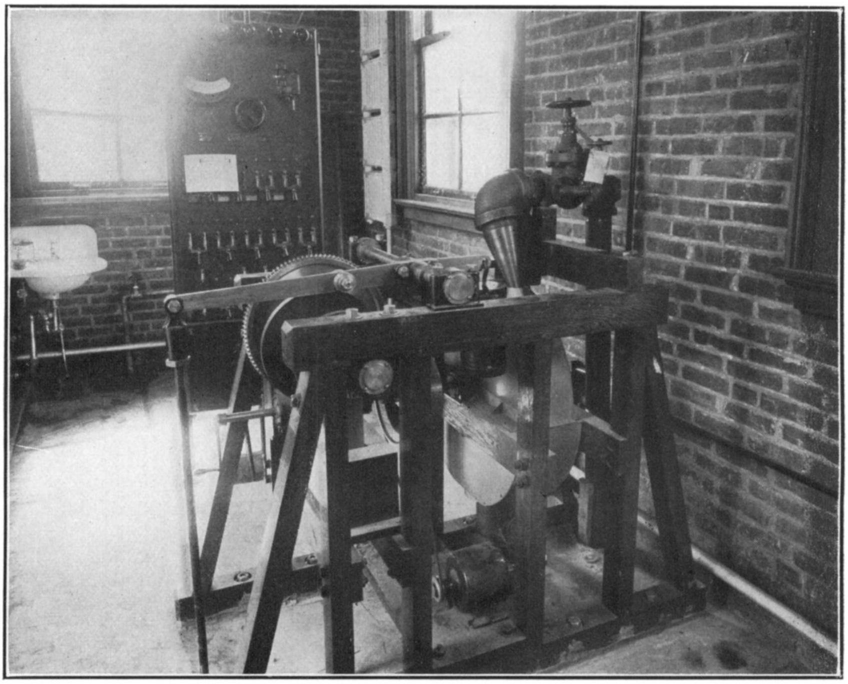

SEWAGE PURIFICATION WORKS
PENNYPACK CREEK SECTION
GENERAL PLAN
OF
SEDIMENTATION TANKS, BASIN
AND
PERCOLATING FILTERS
AUTHORIZED BY ORDINANCES OF COUNCILS APPROVED MAY 10, & JULY 8, 1907
CITY OF PHILADELPHIA
DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS
NOTES
PENNYPACK CREEK
SEDIMENTATION BASIN
SLUDGE LAGOON
PERCOLATING FILTER BEDS
5
4
3
2
1
STATE ROAD
ASHBURNER ST
Sedimentation Basin
Percolating Filter Beds
Dosing Tank
Tank


SLUDGE
Electrical control for Machine in Operating House
Settled sewage to drive waterwheel
Cam control of butterfly valve to cause undulating head upon percolating filter
Waste water from wheel discharged on beds
EMSCHER TANK
CONSTANT HEAD TANK
OPERATING HOUSE
PERCOLATING FILTER
DISINFECTION HOUSE
FINAL SETTLING BASIN
OUTFALL
PROFILE ILLUSTRATING THE PRINCIPLES INVOLVED
—IN THE—
PENNYPACK CREEK SEWAGE DISPOSAL WORKS
—PHILADELPHIA PENNA.—

SECTIONAL DIAGRAM: PENNYPACK CREEK SEWAGE DISPOSAL WORKS, PHILADELPHIA, PA.

engines actuated by a suction gas producer through about three-fifths of a mile of force main to the treatment works located upon ground adjacent to the water filters.

The works designed for a capacity of 2,000,000 gallons a day consist of two circular sedimentation and sludge digestion tanks of the Emscher type, the first full sized tanks under construction in the United States, operated in parallel, in which the sewage is submitted to nominally two hours sedimentation, the effluent from which concentrated in an equalizing or dosing tank is distributed upon a percolating filter.



Operating Mechanism, Controlling Distribution on Percolating Filters, Pennypack Creek Works

The filter covers one acre of area, composed of crushed trap rock, size 1 to 3 inches, with half tile floor drains aligned between two one-half beds, there being five such divisions.

Distribution is by means of 6-inch vitrified pipe in concrete walls, with vertically placed T's at the risers, the latter being of wrought iron, into the top of which, 6 inches above the surface of the filter, are screwed the Taylor square spray nozzles, spaced 10.8 feet apart.

The operating mechanism, somewhat unique in plants of this kind and original with the Bureau of Surveys' assistants, partially developed in the testing station, consists of a water wheel supplied from the dosing tank under a fluctuating head of from 4½ to 7½ feet and wasting to the surface of the filter. An electric motor can be thrown in automatically in case of failure to act on the part of the wheel.

The wheel actuates a shaft upon which are set cams which control the action of a butterfly valve set in the 24-inch distributing line and are in return rendered idle or active by an electrical mechanism operated automatically by float in the dosing tank.

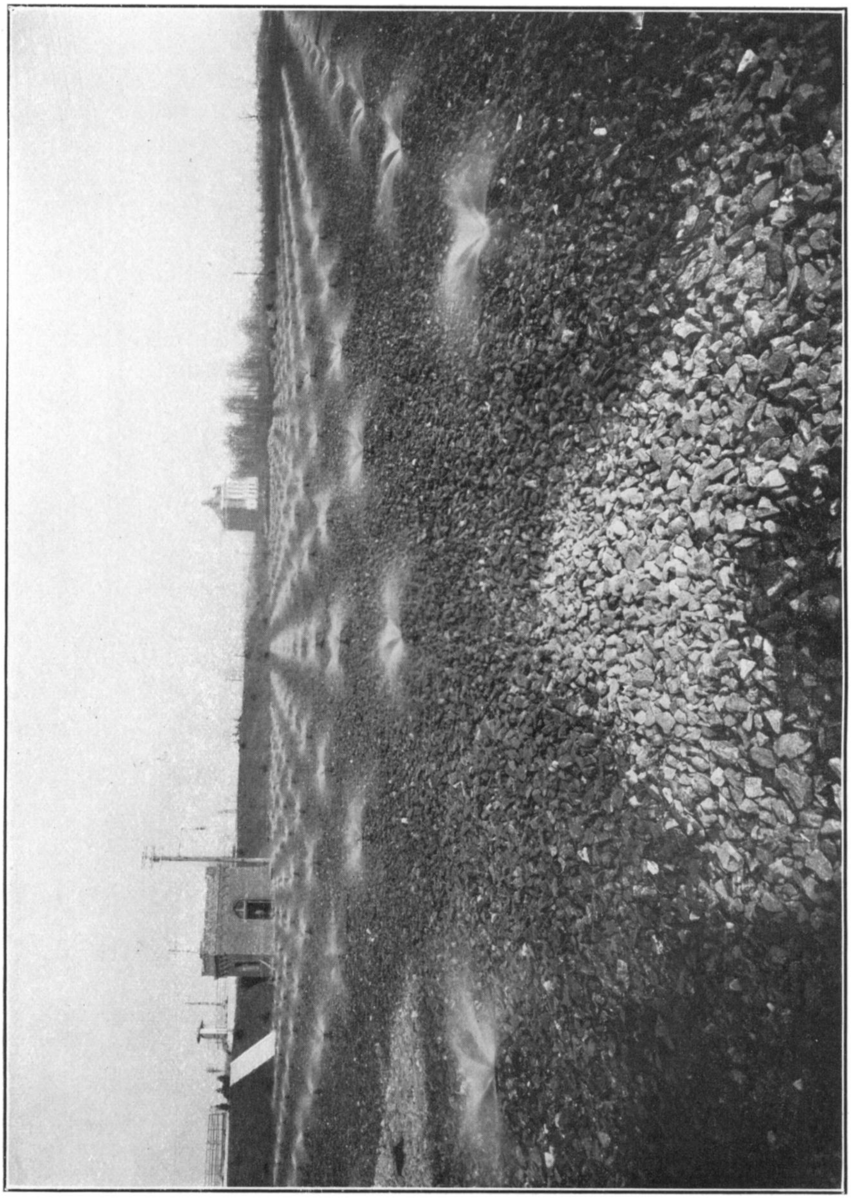
Variations in flow to the works are automatically passed on to the filters by aid of the above mechanism, a quantity greater than the average throwing into action the high rate cam upon the operating mechanism, and a small quantity causing the machine to run idle until a certain height is reached in the dosing tank, when the machine again is thrown into action.

The fluctuating spray from the fixed nozzles carried to a line which produces an overlap of 6 inches secured by the mechanism ensures an equal distribution over the whole filter area and is equal in uniformity of distribution upon the area to the machine distributors in use abroad, but has the added value of a much higher rate of distribution.

It is claimed for it that on account of the evenness of distribution a uniformly satisfactory effluent can be secured even when the filters are operated at a rate of 3,250,000 gallons per acre. When it is considered that 2,000,000 gallons per acre is a high rate under usual conditions, the amount that may be saved by adopting a satisfactory method of distribution in area of land and cost of filters is material.

After passing the filters and in order to comply with a condition of the permit of the State Department of Health, on account of the proximity of the works to the intake of the water filters the effluent is subjected to disinfection by hypochlorite of calcium secured by another device which is effective in avoiding the difficulties which have arisen in many other hypochlorite dosing devices.

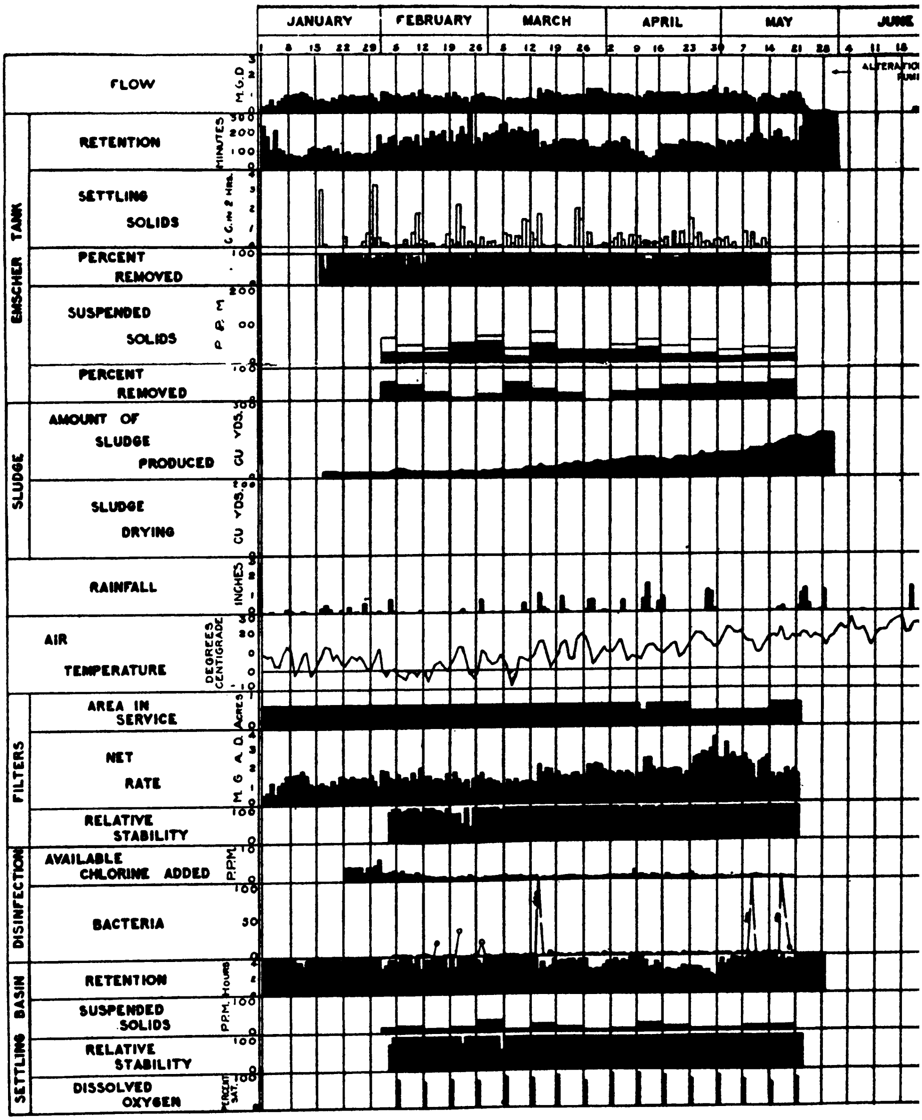
It consists of a mixing tank, upon the floor level, from which the bleach cream is pumped to either of two solution tanks. The product of these tanks is further diluted before it runs through a



Percolating Filters, Pennypack Creek Works, Operating House and Emscher Tanks in Background

PENNYPACK CREEK SE

BUREAU OF SURVEYS



DIAGRAMMATIC HISTORY OF PENNYPAC

CK CREEK SEWAGE DISPOSAL WORKS

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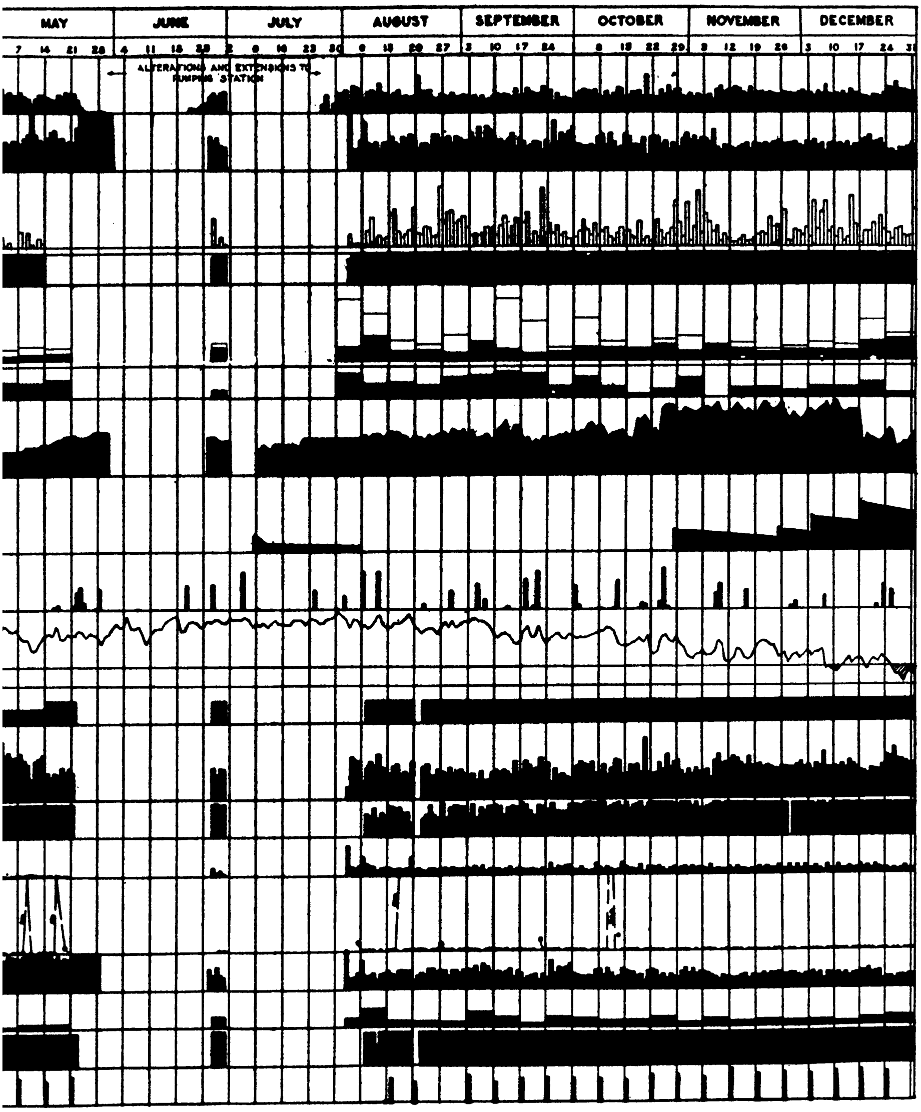


ORY OF PENNYPACK CREEK WORKS 1913

perforated lead pipe, lying horizontally in the effluent conduit thus securing a complete admixture.

With an average flow of 1,000,000 gallons daily, 25 pounds of bleach representing one part per million available chlorine have secured an almost sterile effluent.

Having received its dose, the effluent is retained in the final sedimentation basin, for a nominal period of two and one-half hours where the mineralized solids washed from the percolating filter are deposited. The final effluent escapes over a weir to a semicircular channel terminating in a "V" notch weir the flow over which is recorded by a float operated electric automatic device, registering in the operating house.

The final effluent, discharged to the creek, has been deprived of its suspended solids, is clear, inodorous, perfectly stable and nearly sterilized.

Sludge from the Emscher tanks is discharged, without placing the tanks out of service, by utilizing the head of water upon the sludge discharge pipe, into an underdrained sand bed, where it dries in from a week to ten days.

Sludge digested in an Emscher tank of this type, after some of the troubles due to local conditions have been overcome and after it has reached the ripe stage, when discharged upon this bed, should be inodorous and may be and has been used without offense for the filling of low ground.

The plant as a whole is unobjectionable from odors, due in a large measure to the freshness of the sewage, the rapidity with which it is passed through the works, the practice of keeping cleaned the surfaces with which it comes in contact, and on account of the planting and well trimmed lawns, it is an attractive place to visit.

In all respects it compares favorably with any of the plants of European cities.

The last year's operation of the plant is shown upon accompanying diagram.

Expressed in figures as averages the results of operation are as follows:

1913 Averages

Quantity in m.g.d.	1
Retention in Emscher tanks in hours	2½
Rate of filtration in m.g.d.	1.67
Amount available chlorine added in p.p.m.	1.6
Retention in final settling basin in hours	2.6
Settling solids in Emscher influent cc per liter in 2 hours.	1.23
Settling solids in Emscher effluent	0.02

	Influent	*Effluent*
Suspended solids	64	19
Organic nitrogen	4.7	1.7
Free ammonia	6.1	2.4
Oxygen consumed 30 min. at 100°C	32.1	13.6
Nitrates		2.3
Chlorine	29	
Alkalinity	54	
Bacteria on litmus lactose agar at 37° in 24 hours, total.	83,850	33
Acid formers	60,500	3
Resembling B. Coli.	36,000	2
Dissolved oxygen per cent saturation		73
Relative stability		0.89

Suspended solids

	Total	*Fixed*	*Volatile*
Applied to filters	32	17	15
Effluent No. 1	32	20	12
Effluent No. 3	25	15	10
Effluent No. 5	23	15	8

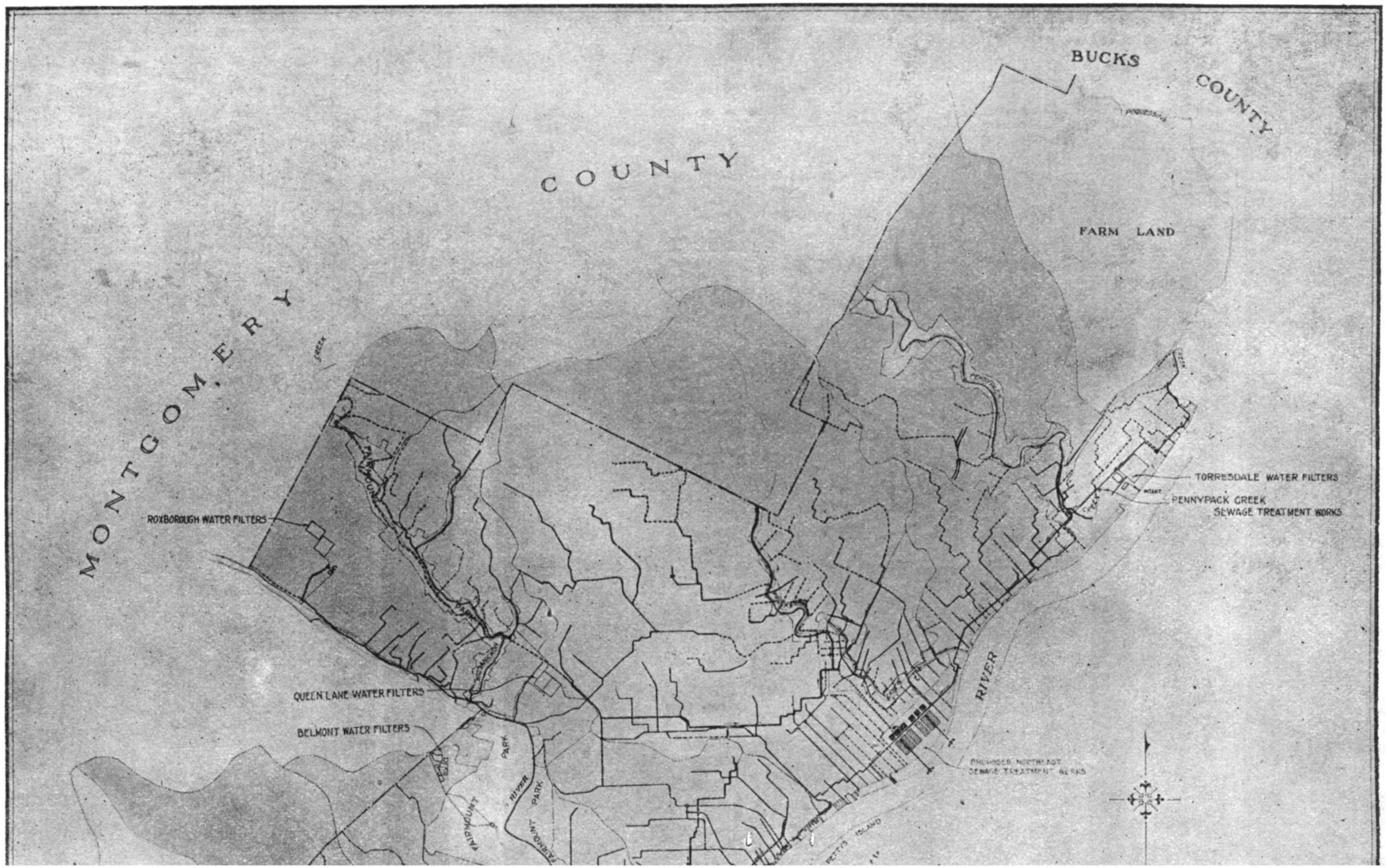
Sludge withdrawn averaged 1.2 cubic yds. per million gallons sewage.

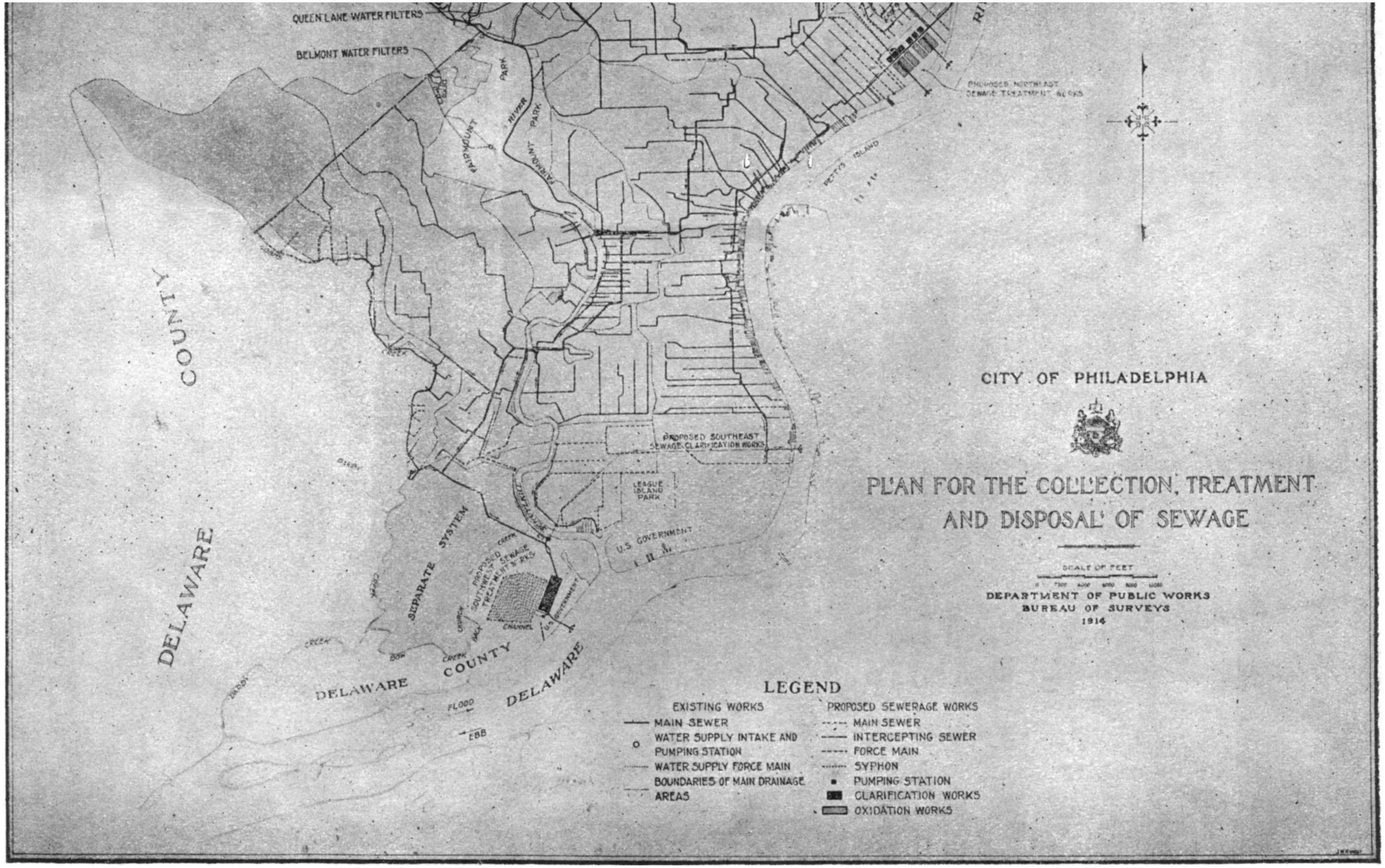
Average analysis of sludge

Per cent moisture	75
Specific gravity	1.11
Percentage of the dry residue that is	
Volatile	40
Fixed	60
Fats	10

Plan for Philadelphia as a whole. The installation at Pennypack Creek is a pattern which may without doubt be applied to the ultimate treatment of the sewage for the entire city, when the sewage is intercepted by marginal sewers along the rivers, and carried to a number of suitable points for treatment.

A scheme to accomplish this which meets with favorable recommedation on the part of the city's officials, provides for clarification works in the northeast, southeast and southwest, discharging the effluents through submerged outlets into the channel of the Delaware


BUCKS COUNTY
POQUESSING
FARM LAND
MONTGOMERY COUNTY
CREEK
PENNYPACK
CREEK
TORRESDALE WATER FILTERS
INTAKE
PENNYPACK CREEK
SEWAGE TREATMENT WORKS
ROXBOROUGH WATER FILTERS
FAIRMOUNT
PARK
WISSAHICKON
QUEEN LANE WATER FILTERS
BELMONT WATER FILTERS
RIVER
PROPOSED NORTHEAST
SEWAGE TREATMENT WORKS
PETTYS ISLAND
FAIRMOUNT
PARK
RIVER
PARK
FAIRMOUNT


CITY OF PHILADELPHIA
PL'AN FOR THE COLL'ECTION, TREATMENT AND DISPOSAL' OF SEWAGE
SCALE OF FEET
DEPARTMENT OF PUBLIC WORKS
BUREAU OF SURVEYS
1914
LEGEND
EXISTING WORKS
MAIN SEWER
WATER SUPPLY INTAKE AND PUMPING STATION
WATER SUPPLY FORCE MAIN
BOUNDARIES OF MAIN DRAINAGE AREAS
PROPOSED SEWERAGE WORKS
MAIN SEWER
INTERCEPTING SEWER
FORCE MAIN
SYPHON
PUMPING STATION
CLARIFICATION WORKS
OXIDATION WORKS
QUEEN LANE WATER FILTERS
BELMONT WATER FILTERS
FAIRMOUNT PARK
RIVER PARK
FAIRMOUNT PARK
PETTYS ISLAND
PROPOSED NORTHEAST SEWAGE TREATMENT WORKS
PROPOSED SOUTHEAST SEWAGE CLARIFICATION WORKS
LEAGUE ISLAND PARK
U.S. GOVERNMENT
SCHUYLKILL
SEPARATE SYSTEM
PROPOSED SOUTHWEST SEWAGE TREATMENT WORKS
CHANNEL
U.S. GOVERNMENT
CHURCH
BACK
CREEK
BOW
CREEK
CREEK
DELAWARE COUNTY
DELAWARE
FLOOD
EBB
DELAWARE
COUNTY

River, utilizing the capacity of the river for the completion of the treatment by dilution and oxidation. A comprehensive report upon this, one of the largest sewage disposal problems, is in course of preparation.

Prophecy. Harbor development, public health, sanitary requirements, the protection of the water supply of this and other cities, the increase in the culture of the people, together with the necessity of maintaining the international reputation of our city, all demand and will ultimately secure the accomplishment of this or a somewhat modified project as essential to proper municipal life in this twentieth century.